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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F04B 49/06

A1

(11) International Publication Number: WO 95/09305

(43) International Publication Date: 6 April 1995 (06.04.95)

(21) International Application Number: PCT/CA94/00517

(22) International Filing Date: 20 September 1994 (20.09.94)

(30) Priority Data:
127,162 27 September 1993 (27.09.93) US

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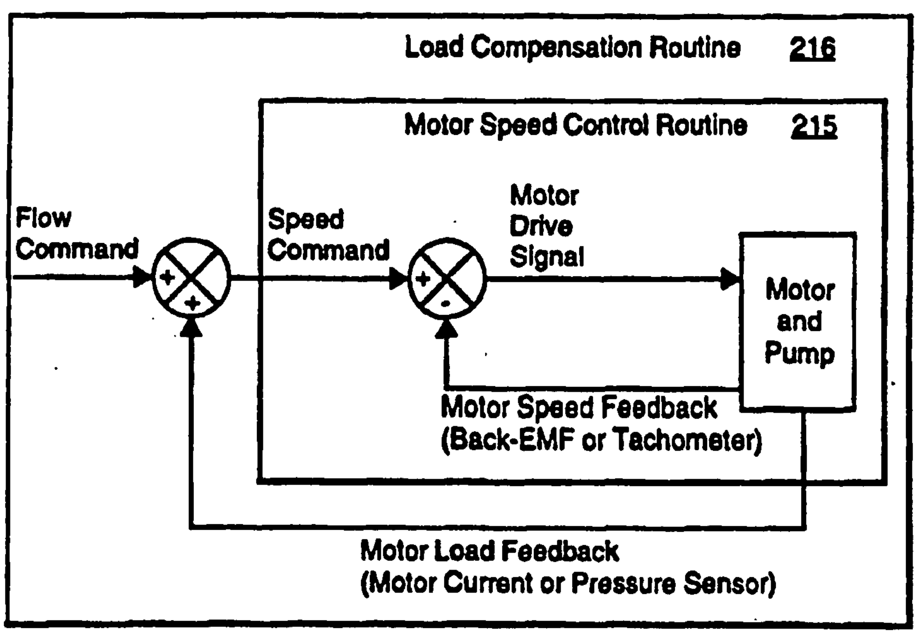
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).

Published
With international search report.

(54) Title: FLOW-METERED PUMPING WITH LOAD COMPENSATION SYSTEM AND METHOD



(57) Abstract

The present invention is an improved flow-metered pumping system using an air-backed diaphragm pump with load compensation. A variable motor speed controller is used to compensate for flow rate reduction caused by pressure effects. When the output pressure on the pump increases to a point where the load on the pump motor exceeds a specified threshold, the motor speed controller increases the speed of the motor to compensate for pressure induced diaphragm distortion losses and to achieve a substantially constant flow rate across a range of pump output pressures.

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FLOW-METERED PUMPING WITH LOAD COMPENSATION SYSTEM AND METHOD

FIELD OF THE INVENTION

The present invention relates generally to metered pumping systems, and particularly to a constant flow pumping system using air-backed diaphragm pumps.

BACKGROUND OF THE INVENTION

Air-backed diaphragm pumps provide an economical and reliable solution for many fluid handling applications. However, they are not suitable for use in a system where a precise or highly stable flow rate is required. The flow rate of such pumps drops with increasing pressure on the pump outlet for several reasons. First, the increased load slows the motor down resulting in a reduced flow rate. Second, the unsupported regions of the pump diaphragm balloon slightly in proportion to the pressure on the outlet, reducing the effective displacement and flow rate of the pump. These diaphragm distortion-based flow rate losses are independent of motor type.

While load induced motor speed reductions can be compensated by using control techniques well known in the art, such correction techniques only counteract about 70% of pressure induced flow rate losses. These techniques do not compensate for diaphragm distortion-based flow rate losses which can account for up to 30% of the pressure induced flow reduction.

One method of eliminating the distortion based diaphragm flow rate loss is to support the diaphragm with some incompressible liquid in a sealed chamber behind the diaphragm. However, such liquid-backed pumps are inefficient and relatively expensive compared to air-backed pumps. Alternatively, a rotor vane pump can be used instead of a diaphragm pump. A rotor vane pump can accurately maintain a specified flow rate through varied outlet pressures. However, rotor vane pumps are very expensive. Moreover, rotor vane pumps cannot pump fluids containing large particulates (> 50 micron) and as a result require the use of micro filters to screen any fluid that

is pumped. Air-backed diaphragm pumps, on the other hand, are inexpensive and can pump fluids with relatively large particulates without impairing the pump.

An object of the invention is to provide a low cost metered flow pumping system that provides substantially constant flow rate across a range of pump output pressures.

Another object of the present invention is to provide a metered flow pumping system that is not sensitive to the presence fluid particulates.

Another object of the invention is to provide a metered flow pumping system using an air-backed diaphragm pump.

SUMMARY OF THE INVENTION

In summary, the present invention is an improved flow-metered pumping system using an air-backed diaphragm pump with load compensation. A variable motor speed controller is used to compensate for flow rate reduction caused by pressure effects. The load on the motor driving a diaphragm pump increases in proportion to the pressure on the output of the pump. This load is measured and used in a feedback loop to increase the speed of the motor. The gain of this feedback loop is set at such a level as to compensate for pressure induced diaphragm distortion losses and to achieve substantially constant flow rate across a range of pump output pressures.

In accordance with an aspect of the invention, a flow-metered pumping system, comprises:

a pump for pumping a liquid;

a pump motor for driving the pump, the pump motor including a motor driver for supplying power to the pump motor;

a speed sensor, coupled to the pump motor, for generating a speed signal corresponding to the pump motor's speed;

a load sensor, coupled to the pump motor, for generating a load signal corresponding to the pump motor's load;

speed control means, coupled to the motor driver and to the speed sensor, for maintaining the speed of the pump motor at a specified speed; the speed control means including a negative feedback means for modulating the amount of power supplied by the motor driver to the pump motor according to the speed signal and the specified speed;

speed compensation means, coupled to the speed control means and to the load sensor, for maintaining a substantially constant flow rate through the pump; the speed compensation means including a positive feedback means for adjusting the specified speed according to the load signal and a specified base speed.

According to a further aspect of the invention, a flow-metered pumping system comprises:

a motor driven pump for pumping a liquid;

a load sensor coupled to the pump for generating a load signal corresponding to loading on the pump;

a speed sensor coupled to the pump for generating a speed signal corresponding to the pump's speed;

speed control means, coupled to the pump, the load sensor, and the speed sensor for maintaining a substantially constant flow of the liquid through the pump corresponding to a specified base pump speed; the speed control means including feedback means for modulating said pump's speed according to the load signal, the speed signal, and the specified base speed such that the pump's speed is increased by the speed control means as the load signal increases in value.

In accordance with a further aspect of the invention, a method of flow-metered pumping comprises:

providing a pump for pumping a liquid;

operating a pump motor for driving the pump; the pump motor including a motor driver for supplying power to the pump motor;

measuring the pump motor's load;

measuring the pump motor's speed;

maintaining a substantially constant flow rate through the pump, including modulating the pump motor's speed according to measured load, the measured speed and a specified base flow rate such that the pump motor's speed is increased as the measured load increases.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects and features of the invention will be more readily apparent from the following detailed description and appended claims when taken in conjunction with the drawings, in which:

Figure 1 is a block diagram of a washing machine system that uses the flow-metered pumping system of the instant invention to provide a constant flow rate of chemical solution to the washing machines.

Figure 2 is a block diagram of the flow-metered pumping system of the instant invention.

Figure 3 depicts a pump motor drive circuit and the drive and measurement signals associated therewith.

Figure 4 depicts a graph showing the motor speed for an air-backed diaphragm pump needed to maintain a constant flow rate for a range of motor loads.

Figure 5 is a flow chart for a dual control loop to maintain a constant flow through an air-backed diaphragm pump.

Figure 6 is a timing diagram showing the sequence of flow control steps used in the dual control loop embodiment of the present invention.

Figure 7 is a flow chart for an alternate control method to maintain a constant flow through a pump.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a washing machine system 100 utilizing metered flow pump controllers 102-1, 102-2, 102-3 of the present invention. The washing machine system includes washing machines 104-1 to 104-6 which receive chemical solution pumped at a measured flow rate by pumps 111-116. These metered-flow pumps are controlled by metered flow pump controllers 102-1 to 102-3. Each pump controller 102

can control up to two pumps. Each of the two pumps attached to one controller can feed a separate washer or they both can be attached to a single washer to provide double the maximum flow of solution to that washer. Washer 104-1 is shown connected to a single pump 111, which is one of two pumps controlled by metered flow controller 102-1. Pump 111 draws chemical solution from main conduit 30 and delivers the solution to washer 104-1 via feed conduit 31. Other washers in the system are connected to the pumps and main conduit in a similar manner.

Master controller 120 coordinates the various subsystems of the washing machine system. It communicates to the pump controllers and washing machines over serial connection line 121. In the instant embodiment, this serial connection is implemented using a RS 485 communication protocol. The master controller 120 specifies desired flow rates to the metered-flow pump controllers 102 over serial connection line 121.

Figure 2 shows the metered flow pumping system of the instant invention including the controller 102, and two pumps 111, and 112. The instant invention has the capability to independently regulate two pumps but can be operated to control a single pump or multiple pumps without departing from the scope of the invention. Each pump 111, 112 consists of a pulse controlled permanent magnet DC motor 130, motor driver 132, and an air-backed diaphragm pump 134. The motor drivers 132 deliver power to motors 130 according to the signals on pulse length modulation (PLM) signal lines 136 which are output from the controller 120.

The controller 102 consists of a CPU 210 which executes software 301 stored in a ROM 211 in conjunction with a RAM 212 for manipulating controller hardware to perform control functions. The ROM 211 stores control programs 214-216 and data tables 218-221. The data tables hold parameters used by the controller software in controlling the pump motors. The controller also has a timer 213 for scheduling the execution of control

functions. A-D converters 230, 231 translate analog signals from the pump motors into digital values that are used by the CPU 210. The controller has output port registers 232 and 233 connected to PLM signal lines 234, 235. The CPU 210 writes to these registers to control the PLM signal lines 234, 235. Finally, the controller has I/O interface 240 sending and receiving messages to and from an outside source using the RS 485 communication protocol. In the preferred embodiment, all of the controller elements are contained within a 68HC705B5 single chip micro-controller, but they can be built using discreet components without departing from the scope of the invention. Other micro-controllers, preferably with built-in analog to digital converters, could be used in alternate embodiments.

The controller software 214-216 instructs the CPU 210 to calculate the amount of time that the PLM signals output on lines 234, 235 should be ON in a given cycle according to the control algorithms discussed below. The CPU 210 programs the timer 213 to generate a signal at the specified time interval. The CPU 210 writes a high value to the output port corresponding to a PLM signal to turn on that PLM signal and writes a low value to the same output port to turn off the PLM signal when the timer 213 indicates that the specified time has elapsed.

The PLM signals are periodic (8.192 ms cycle time in the instant embodiment) and control power to the pump motor. When a PLM signal is high the motor is supplied with power that causes acceleration. When the PLM signal is low the power is cut off and the motor coasts. The speed of a motor can be controlled by adjusting the duty cycle of the PLM signal. The more that the signal is "on" during a cycle, the faster the motor will rotate.

Referring to Figures 2 and 3, each motor provides the controller with two sense signals. The motor back-emf signals received on lines 241, 242 are used by the controller as a measure of motor speed. Motor speed can be measured by other means such as an encoder or tachometer

without departing from the scope of the invention. The motor current signals received on lines 243 and 244 are used by the controller as an indication of the load on each motor. Motor loading can also be measured by other means such as a torque or pressure sensor without departing from the scope of the invention.

The measurement of the back-emf signal is synchronized with the PLM drive signal. The controller software reads the back-emf signal at the end of the PLM drive cycle just before the PLM signal is turned on for the next drive cycle. This timing allows the measurement of a motor's back-emf without interference from the PLM drive signal. The timing of the motor current signal is not critical. In the instant embodiment, the motor current is read in the middle of the PLM cycle but can be read at other points in the PLM drive cycle without effecting the operation of the invention.

Figure 4 depicts a motor speed and motor load graph that shows relationship between motor speed and motor load for an air-backed diaphragm pump for two different flow rates. As shown, in order to maintain a constant flow rate through the pump, as the load (i.e., output pressure) on the pump increases past a threshold load, the motor speed must be increased in order to maintain a constant flow rate. Also shown in Figure 4 is that the threshold load is different for different flow rates and that different positive feedback gains are needed to maintain different flow rates.

Figure 5 shows the feedback control system implemented by the controller 210. The controller uses a dual feedback loop system to control the flow rate through the motor. The controller 210 executes a first motor speed feedback routine 215 to control motor speed. The controller uses a specified Speed Command value as the target motor speed. It gets a back-EMF signal from the motor that is proportional to motor speed. The timer is used to signal the controller when to read the back-EMF signal. The A-D converters are used to convert the analog back-emf signal

into a digital signal for manipulation by the CPU. The controller uses the digital conversion of the back-EMF signal and speed command value to select the duty cycle for the PLM signal. An error value proportional to the difference between the actual speed (as reflected by the digitized back-EMF signal) and the speed command value is generated by the controller. The change in the PLM signal duty cycle is determined by multiplying the error by a proportional gain signal and adding the integral of the error with respect to time multiplied by an integral gain value. This change value is added to a "steady state" PLM duty cycle value that is determined by multiplying the speed command value by an initial gain. The following pseudocode shows the operation of the controller software implementing the first feedback loop:

```
Speed Control
{
Receive Back_emf
error = SpeedCommand - Back_emf
accum = accum + (error * IntegralGain)
clip accum to predefined range
temp = (SpeedCommand * InitialGain) +
       (error * ProportionalGain) + accum
clip temp to predefined range
PLM duty cycle = temp
--  controller will continue to drive motor with
this computed
--  PLM duty cycle until this value is updated
}
```

This routine is executed once during each PLM drive cycle after the back-emf has been read.

The control software includes a second feedback loop routine 216 to adjust the speed command value used by the first feedback loop to compensate for diaphragm distortion-induced flow rate losses at high output pressures. The controller receives an externally sourced flow command value over the RS 485 link that specifies the target flow rate through the pump. The flow command value in the preferred embodiment is actually a base pump speed value which will achieve a desired flow rate if the load on the pump motor is very low.

The controller gets a motor current signal from the motor that is proportional to the load on the motor. The controller uses the motor current and flow command value to select an appropriate speed command value. The motor current is compared to a threshold value. If the motor current is greater than the threshold, the difference between the motor current and the threshold is multiplied by a flow gain and added to the flow command value to generate a new speed command value for the motor speed feedback routine 215. As the load increases, the speed command value is increased to compensate for throughput losses caused by pressure effects. The following pseudocode shows the operation of the controller software implementing the second control loop:

```
Load Compensation
     {
     Receive MotorCurrent
     if MotorCurrent > Threshold then
          {
          SpeedCommand = FlowCommand +
            ( (MotorCurrent - Threshold) * FlowGain )
          }
     else SpeedCommand = FlowCommand
     Return
     }
```

The positive feedback gain coefficient, FlowGain, in this routine is computed from flow and speed measurements of actual air-backed diaphragm pumps so that the flow rate of fluid through the pump remains substantially constant for a specified range of output pressures or motor loads. This routine is executed once during each PLM cycle just after the motor current signal has been read.

Each time a new flow command value is received over the RS 485 port the CPU 210 executes an initialization routine 213. The initialization routine selects values for the flow gain, proportional gain and integral gain, and motor current threshold using the data tables 218-221. There is a separate table for each of these parameters. Each table consists of a sequence of flow rate / value

pairs. The value paired with a flow rate is the optimized parameter value corresponding to that flow rate. These pairs are stored in the table in sequence of increasing flow rates. The initialization routine scans the table starting at the highest flow rate and locates the largest flow rate that is less than or equal to the new flow command. The parameter is initialized to the value corresponding this located flow rate. Using a parameter lookup table indexed according to flow rate allows the controller software to be optimized for broad range of flow rates. In the preferred embodiment, the parameters can also be down-loaded over the serial link, allowing the master controller to optimize the control software for certain situations.

The initialization routine then ramps the motor speed up or down to the desired flow rate by increasing or decreasing speed command value by a constant amount each cycle until the target motor speed is reached. Once up to speed, the initialization routine then enables the dual loop control algorithm to control speed and compensate for load. The following pseudocode shows the flow of the initialization routine:

```
Initialize
     {
     Receive FlowCommmand
     if FlowCommand is New
          {
     Threshold = ThresholdTable(FlowCommand)
     FlowGain = GainTable(FlowCommand)
     InitialGain = InitGainTable(FlowCommand)
     ProportionalGain = PropGainTable(FlowCommand)
     Ramp SpeedCommand up or down
       until SpeedCommand = FlowCommand
          }
     Return
     }

     ThresholdTable(FlowCommand)
          -- Note structure of Threshold table is
          -- Table(Flow(1:N),Threshold(1:N))
          Index = 1
          Do For Index = 1 to N
               {
               If Flow(Index) ≤ FlowCommand {
```

```
            Return (Threshold(Index)) }
        }
    Return (Threshold(N))

    -- The FlowGain, InitialGain and ProportionalGain
         functions all
    -- work in the same way as the ThresholdTable
         function, except
    --  that the flow value breakpoints may be
         different in each table.
```

Figure 6 is a timing diagram showing the timing relationship between the measurement of motor signals, the motor drive signals, and the software implementing the dual loop control algorithm. When the PLM motor drive signal is high in Figure 6, the motor is receiving power that causes acceleration. When the motor drive signal is low the motor receives no power and coasts. The back-EMF waveform represents the back-emf of the motor driven by the PLM motor drive signal. The current sense waveform shows the current through the motor driven by the PLM motor drive signal.

Motor current and back-emf measurement timing is linked to the motor drive timing because the back-emf must be sensed at the end of the drive interval just before the "on" portion of the drive waveform begins. The current measurements are made near the middle of the PLM drive cycle. The PLM motor drive signal is turned on and off according to the output of the controller timer. That same timer is used to signal the controller software to measure current and back-emf, thereby insuring that there is a precise relationship between the PLM drive signal and the motor signal measurement points.

The motor current is read shortly after the motor drive signal is turned off. The load compensation routine 216 then executes and calculates a speed command value for use by the first control loop routine. The timer is programmed to cause a back-emf read a specified time before the start of the next PLM drive cycle. The speed control routine 215 is executed after the back-emf has been measured to calculate a new duty cycle value for the PLM

drive signal that will be used by a counter to control the "on" portion of the subsequent PLM duty cycle.

Figure 7 shows the flow of an alternative method of controlling the motor using only a single control loop. The controller implements a signal feed back loop to control motor speed. The controller uses a specified speed command value that is the target motor speed. It gets a signal from the motor, motor current that is proportional to the load on the motor. The controller uses the motor current and speed command value to select the duty cycle for the PLM motor drive signal, increasing the duty cycle of the PLM motor drive signal as the load increases.

Controller software implementing a single control loop method has only a single feedback loop that performs both the speed control and load compensation functions. The sequence of instructions in the software routine is similar to the first feedback loop control routine discussed above. In this embodiment, however, the specified flow command value is used instead of a speed command value as the target motor speed. In addition load compensation is implemented by directly adjusting the PLM duty cycle rather than adjusting the target motor speed. The following pseudocode shows the operation of the controller software implementing this feedback loop:

```
Speed Control with Load Compensation
     {
     Receive MotorCurrent
     Receive Back_emf
     error = FlowCommand - Back_emf
     accum = accum + (error * IntegralGain)
     clip accum to predefined range
     temp = (FlowCommand * InitialGain) +
            (error * ProportionalGain) + accum
     if MotorCurrent > Threshold then
          temp = temp + ((MotorCurrent - Threshold) *
          FlowGain)
     clip temp to predefined range
     PLM duty cycle = temp
     }
```

This routine is executed once during each PLM cycle after motor current and back-emf have been measured.

Although preferred embodiments of the invention are described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

CLAIMS

1. A flow-metered pumping system, comprising:

a pump for pumping a liquid;

a pump motor for driving said pump, said pump motor including a motor driver for supplying power to said pump motor;

a speed sensor, coupled to said pump motor, for generating a speed signal corresponding to said pump motor's speed;

a load sensor, coupled to said pump motor, for generating a load signal corresponding to said pump motor's load;

speed control means, coupled to said motor driver and to said speed sensor, for maintaining the speed of said pump motor at a specified speed; said speed control means including a negative feedback means for modulating the amount of power supplied by said motor driver to said pump motor according to said speed signal and said specified speed;

speed compensation means, coupled to said speed control means and to said load sensor, for maintaining a substantially constant flow rate through said pump; said speed compensation means including a positive feedback means for adjusting said specified speed according to said load signal and a specified base speed.

2. The flow-metered pumping system of claim 1, wherein said speed compensation means adjusts said specified speed in accordance with the following equation:

$$\text{Specified Speed} = \text{Base Speed} + (\text{PumpLoad} - \text{Threshold}) * \text{Gain}$$

when said load on said pump exceeds said Threshold, where PumpLoad is a pump load value corresponding to said load signal, Threshold is a predefined pump load threshold value and Gain is a predefined positive feedback gain value.

3. A flow-metered pumping system comprising:

a motor driven pump for pumping a liquid;

a load sensor coupled to said pump for generating a load signal corresponding to loading on said pump;

a speed sensor coupled to said pump for generating a speed signal corresponding to said pump's speed;

speed control means, coupled to said pump, said load sensor, and said speed sensor for maintaining a substantially constant flow of said liquid through said pump corresponding to a specified base pump speed; said speed control means including feedback means for modulating said pump's speed according to said load signal, said speed signal, and said specified base speed such that said pump's speed is increased by said speed control means as said load signal increases in value.

4. The flow-metered pumping system of claim 1 or 3, wherein:

said pump consists of an air-backed diaphragm pump.

5. The flow-metered pumping system of claim 3, wherein said feedback means modulates said pump's speed in accordance with the following equation:

Pump Speed = Base Speed + (PumpLoad - Threshold) * Gain

when said load on said pump exceeds said Threshold, where PumpLoad is a pump load value corresponding to said load signal, Threshold is a predefined pump load threshold value and Gain is a predefined positive feedback gain value.

6. The flow-metered pumping system according to any one of the preceding claims, wherein:

said pump motor consists of a pulsed activation, permanent magnet DC motor;

said speed signal corresponds to said pump motor's back-emf.

7. The flow-metered pumping system according to any one of the preceding claims, 7, wherein:

said pump motor consists of a pulsed activation, permanent magnet DC motor;

said load signal corresponds to said pump motor's current.

8. The flow-metered pumping system according to any one of the preceding claims, wherein:

said pump motor consists of a pulsed activation, permanent magnet DC motor;

said load signal corresponds to said pump motor's current;

said speed signal corresponds to said pump motor's back-emf.

9. A method of flow-metered pumping consisting of:

providing a pump for pumping a liquid;

operating a pump motor for driving said pump, said pump motor including a motor driver for supplying power to said pump motor;

measuring said pump motor's speed;

maintaining the speed of said pump motor at a specified speed, including modulating the amount of power supplied by said motor driver to said pump motor according to said speed signal and said specified speed;

measuring said pump motor's load; and

maintaining a substantially constant flow rate through said pump, including adjusting said specified speed according to said measured load and a specified base speed.

10. A method of flow-metered pumping consisting of:

providing a pump for pumping a liquid;

operating a pump motor for driving said pump; said pump motor including a motor driver for supplying power to said pump motor;

measuring said pump motor's load;

measuring said pump motor's speed;

maintaining a substantially constant flow rate through said pump, including modulating said pump motor's speed according to measured load, said measured speed and a specified base flow rate such that said pump motor's speed is increased as said measured load increases.

11. The method of claim 9 or 10, wherein:
said pump consisting of an air-backed diaphragm pump.

12. The method of claim 11, wherein said step of maintaining a substantially constant flow rate includes adjusting said specified speed in accordance with the following equation:

Specified Speed = Base Speed + (PumpLoad - Threshold) * Gain

when said load on said pump motor exceeds said Threshold, where PumpLoad is said measured pump motor's load, Threshold is a predefined load threshold value and Gain is a predefined positive feedback gain value.

13. The method of claim 9 or 10, wherein:
said pump motor consisting of a pulsed activation, permanent magnet DC motor;
said load measuring step including measuring said pump motor's current;
said speed measuring step including measuring said pump motor's back-emf.

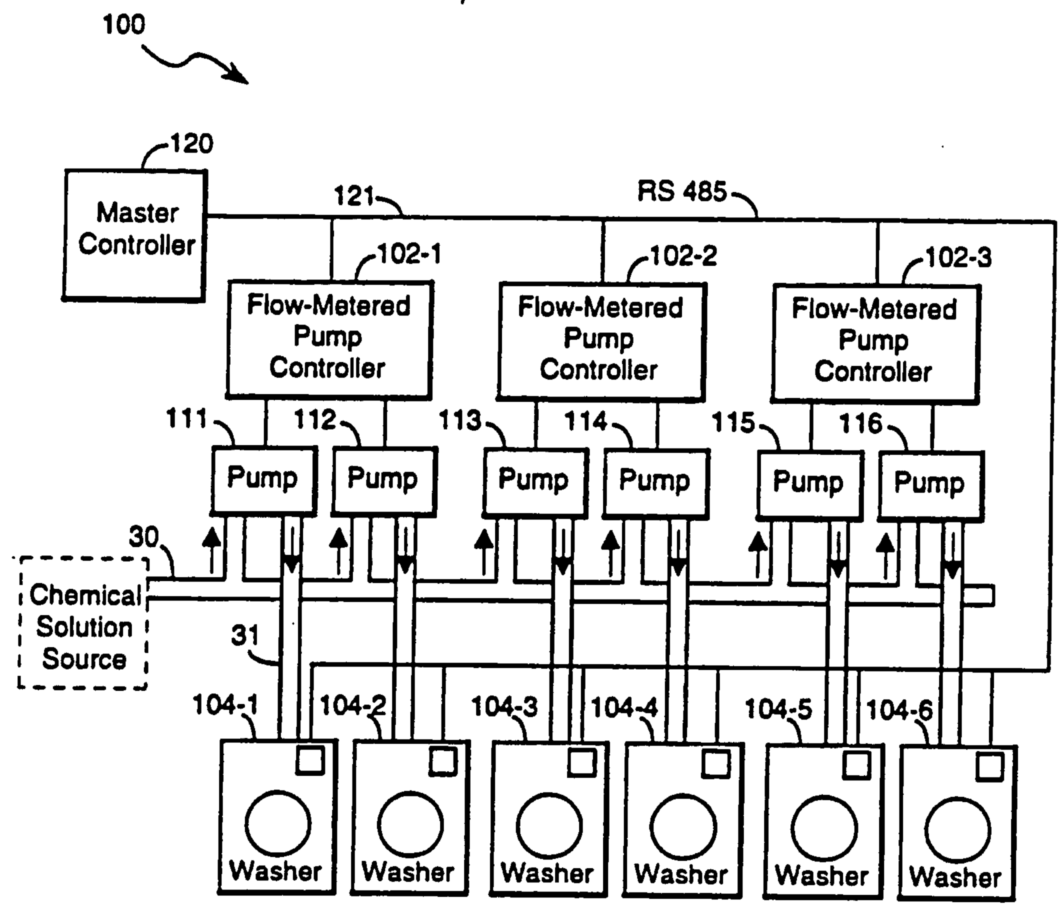
100
120
Master Controller
121
RS 485
102-1
102-2
102-3
Flow-Metered Pump Controller
Flow-Metered Pump Controller
Flow-Metered Pump Controller
111
112
113
114
115
116
Pump
Pump
Pump
Pump
Pump
Pump
30
Chemical Solution Source
31
104-1
104-2
104-3
104-4
104-5
104-6
Washer
Washer
Washer
Washer
Washer
Washer

FIGURE 1

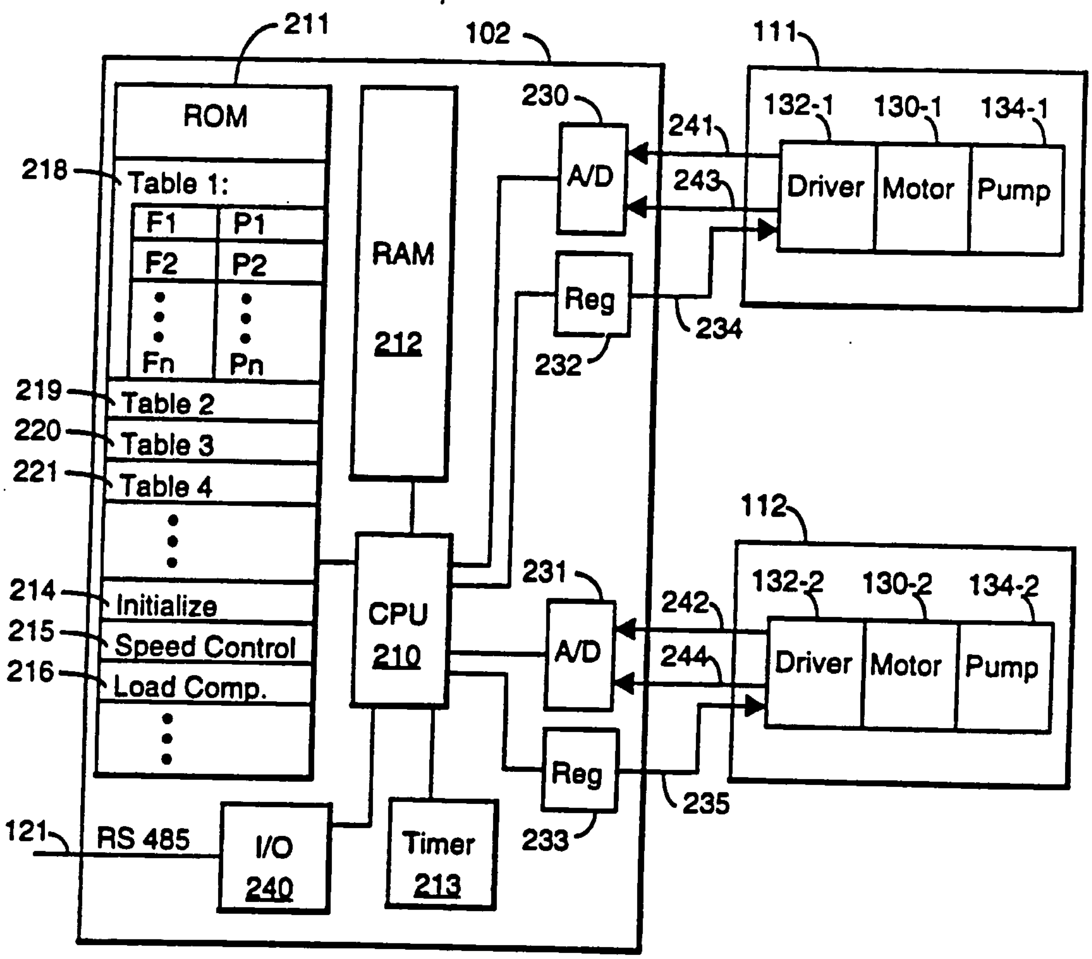

FIGURE 2

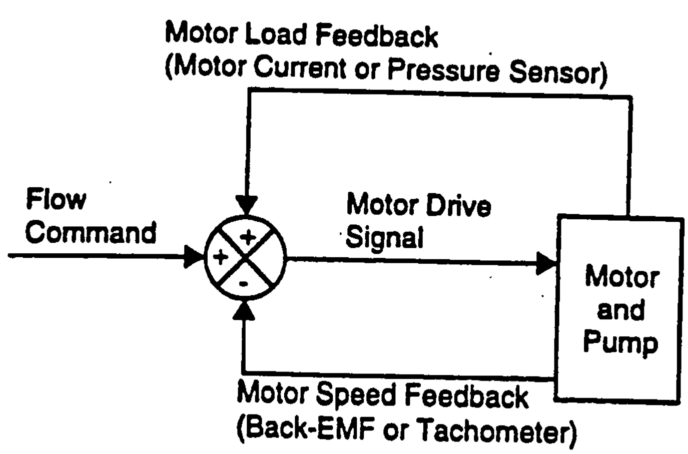

FIGURE 7

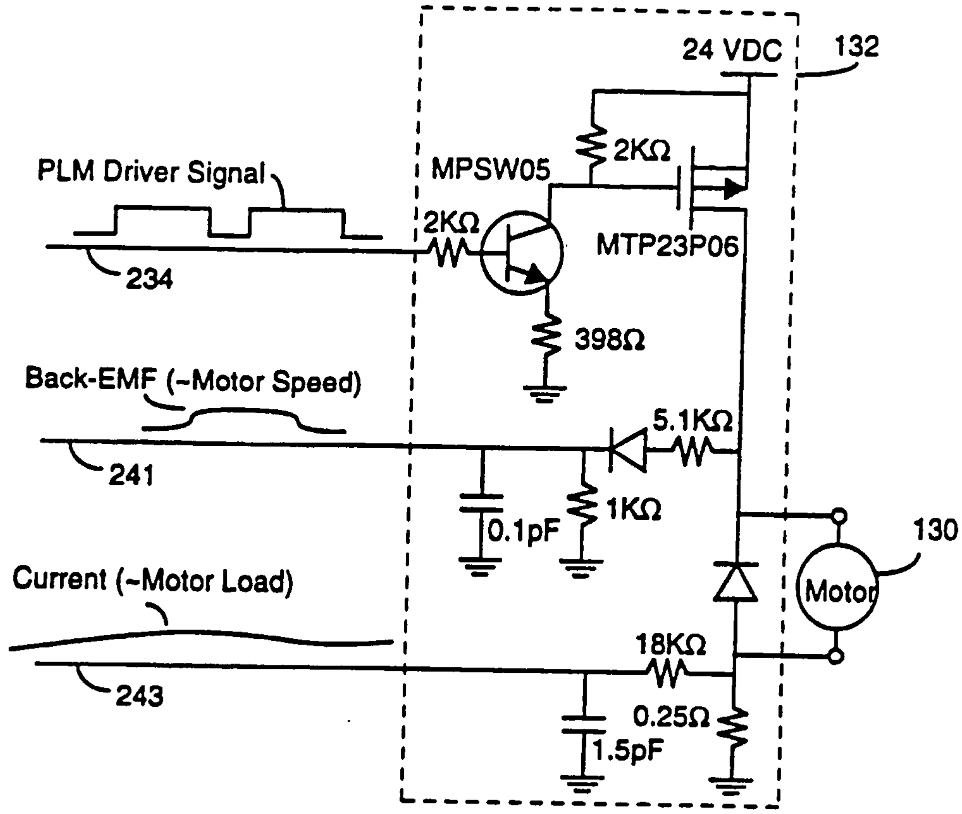

FIGURE 3

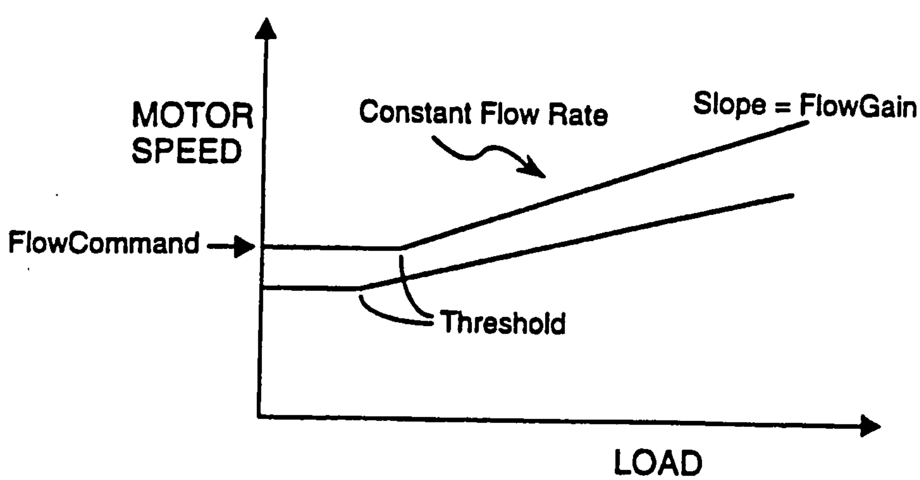

FIGURE 4

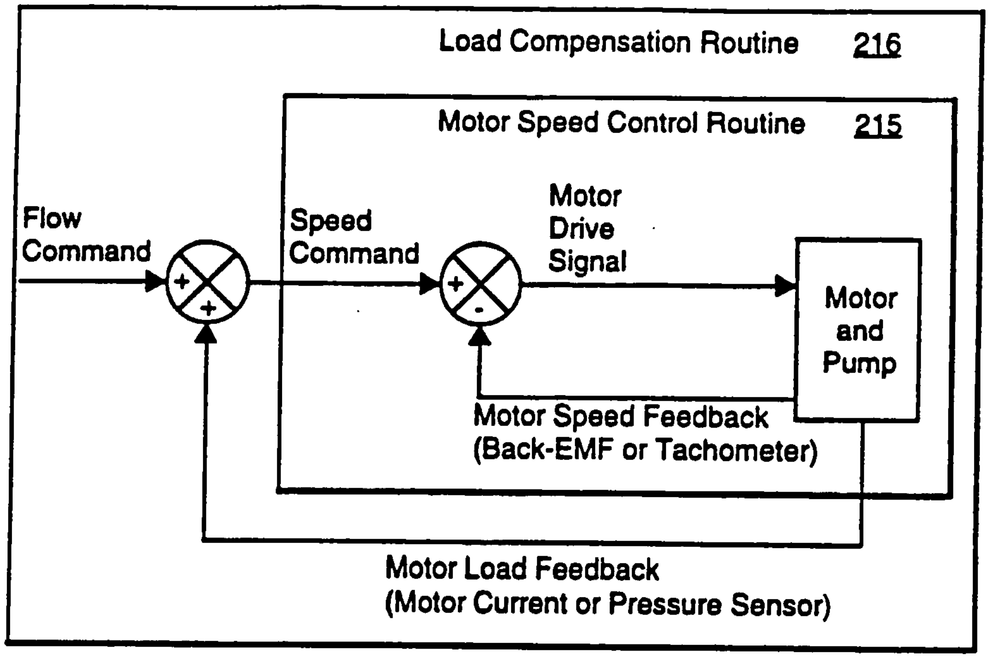

FIGURE 5

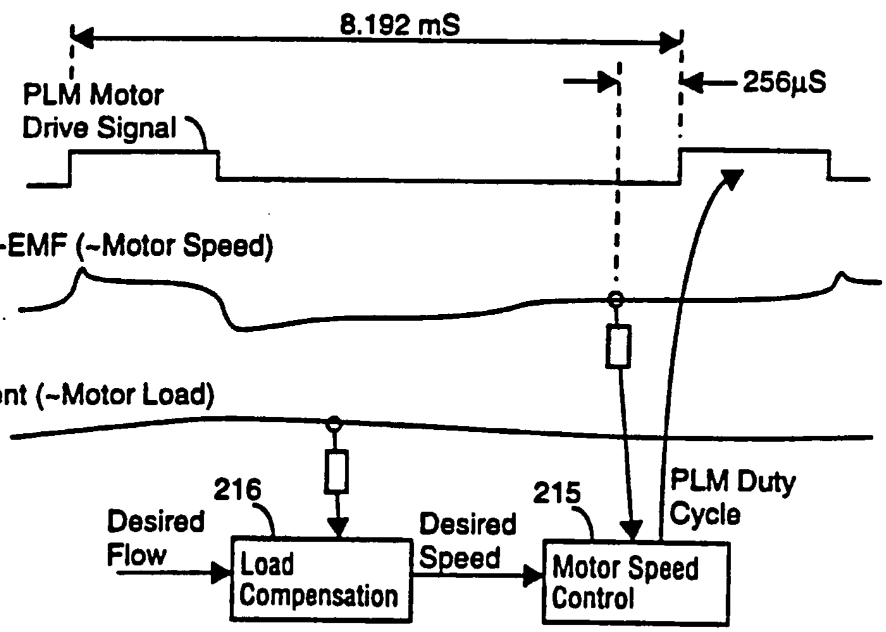

FIGURE 6

INTERNATIONAL SEARCH REPORT

Inte nal Application No
T/CA 94/00517

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F04B49/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F04B G05D G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 163 818 (BETSILL ET AL) 17 November 1992	1,3,7,9, 10
A	see column 5, line 25 - column 10, line 48; figures 4-12	2,5,6,8, 12,13

Y	US,A,4 384 825 (THOMAS ET AL) 24 May 1993	1,3,7,9, 10
A	see column 2, line 16 - column 4, line 56; figures 1,2	4,11

A	US,A,5 141 402 (BLOOMQUIST ET AL) 25 August 1992 see column 3, line 30 - column 7, line 10; figures 1-6	1,3,9,10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
23 December 1994	13.01.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Calarasanu, P

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 552 513 (MILLER ET AL) 12 November 1985 see column 6, line 21 - column 8, line 56; figures 6-8 ---	1-3,5,6, 9,10,12
A	US,A,4 209 258 (OAKES) 24 June 1980 see column 2, line 56 - column 4, line 41; figures 1A,1B -----	1,7-9,13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 94/00517

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5163818	17-11-92	NONE		
US-A-4384825	24-05-83	CA-A-	1150802	26-07-83
US-A-5141402	25-08-92	EP-A-	0574623	22-12-93
US-A-4552513	12-11-85	NONE		
US-A-4209258	24-06-80	NONE		